Notes

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Date:	Measurement Errors from Event Clusters
Subject:	
CC:	

We give a summary of estimates of measurement errors based on differences between arrival times that are more or less independent of travel time model and origin times.

To illustrate the approach we assume initially that all events in a given cluster occur at the same hypocenter. We also assume that arrival times, $arrtime_i$ and $arrtime_j$, are available for n_{ij} common events at a given station pair, i and j. Then we can used the following standard additive model to estimate standard deviations of measurements of individual station/phase pairs:

$$SDi^2 + SDj^2 = SUM\ (arrtime_i - arrtime_j)^2/(n_{ij} - 1)$$

where SDi and SDj represent standard deviations of phase i and phase j at the same of different stations for events of a given cluster. This is an over-determined system of equations which allows the estimation of SD_i and SD_j. With many clusters we can get several estimates of SD_i for a given station. Figure 1 shows examples of such standard deviations for 4 stations plotted as a function of epicentral distance between station and clusters. The smoothed curve is also drawn in the figures. The curve was based on about 1,500 individual station estimates from 30 event clusters throughout the area of Calibration Group 2. The larger standard deviations at around 15 degrees, apparent on for individual stations as well as the smoothed curve correspond to the well known triplication effects.

In practice events in a cluster are not occurring at identical hypocenters, which was taken into consideration in the calculations. Events were randomized over an area with a radius of the JHD locations. The standard deviation of the theoretical travel time differences (from IASPEI91) to a station pair was compared with that of the observed arrival time differences. Only cases of station paris where the standard deviation of the theoretical time differences were less than 5% of the standard deviations of the observed differences were used. Also, only arrivals times used in the JHD were included, which means that outliers were screened out.

Figure 2 compares the smoothed distance dependence for the measurement errors with the distance dependence of the CUB model error curve. Both curve are similar in shape and have a pronounced peak at around 15 degrees. The CUB model probably includes scatter from both measurement errors and errors in origin times. The comparison raises the possibility of getting an independent estimate of the overall standard model error for a cluster.

For a given cluster the average arrival time differences to a given station pairs is compared with travel time difference calculated from the CUB or other model. The difference between the two differences represent a residual of the model. With the many such residuals a standard deviation can be calculated for all or subsets of the data. Measurement errors and the spread of the cluster have, however, to be accounted in the error budget.
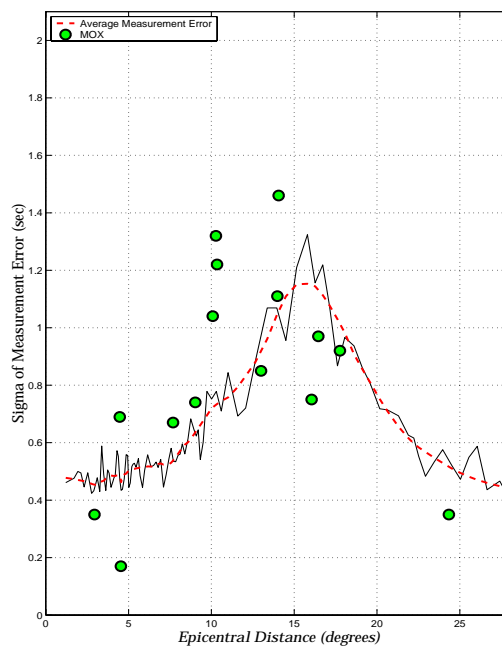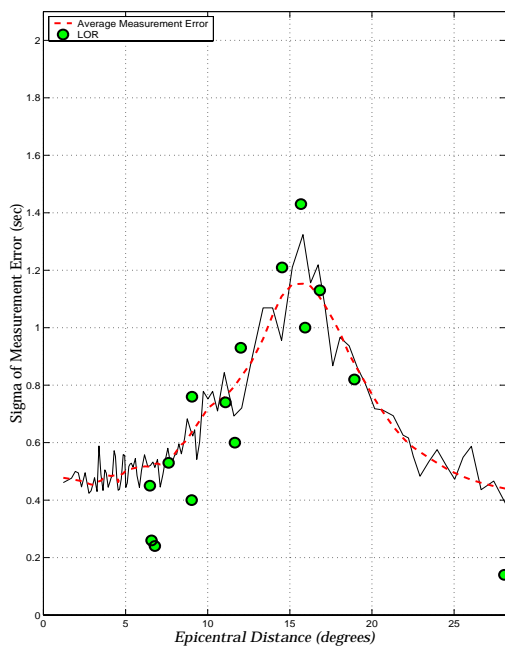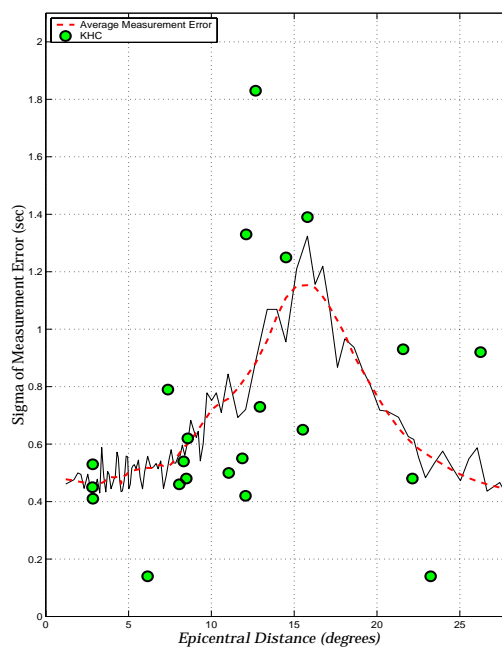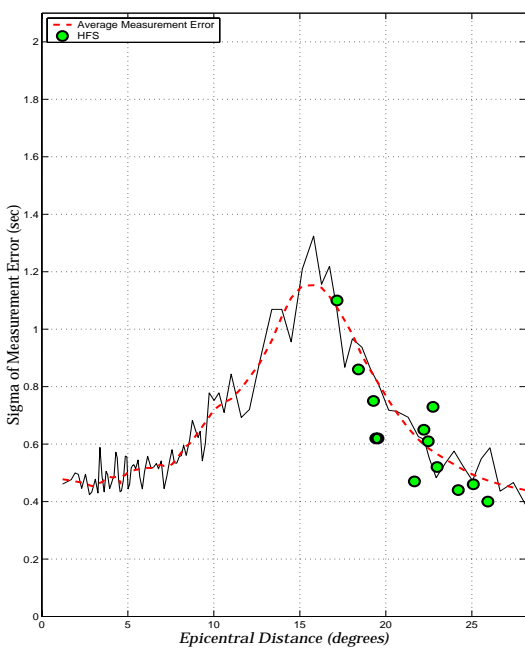
Figure 1. Standard deviation of measurement errors for stations HFS (upper left), KHC (upper right), LOR (lower left) and MOX (lower right) for different clusters plotted as a function of epicentral distance. The curves represent average (smoothed) and un-smoothed for all stations and all clusters.
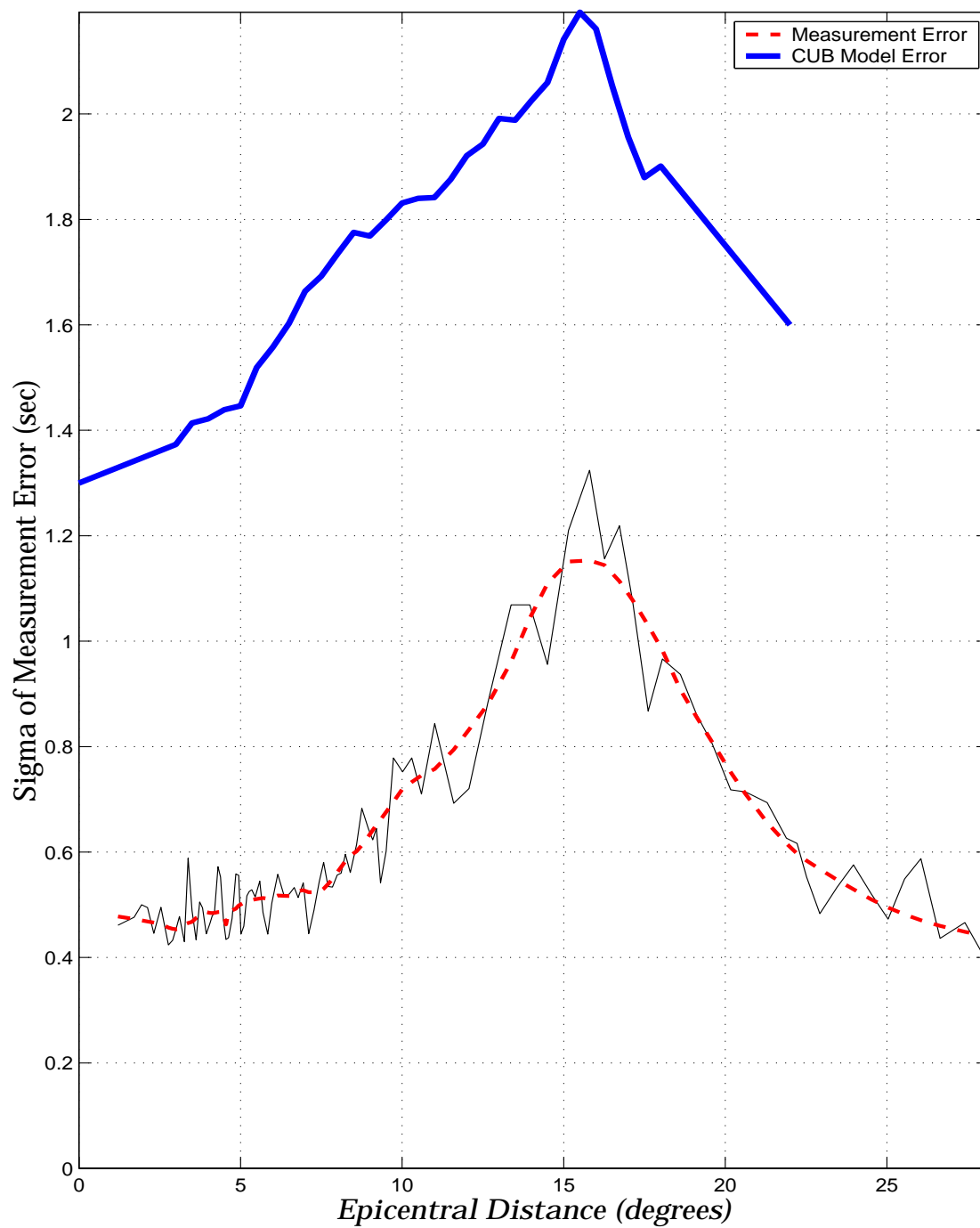
Figure 2. Comparison of measurement errors (lower curves) and model errors (upper curve) as a function of epicentral distance.